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Multi-Scale Atmospheric Numerical Modeling and Data Assimilation for Planetary Applications – With a Focus on Mars

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The work plan for year 1 of the proposal was as follows:

Year 1:

Validation of released code (Ewald): the code is still in beta release from NCAR, and we intend to undertake a full "shake down" of the model, including real-time forecast comparisons and testing of basic conservation properties in idealized versions of the model, real-time weather forecasts for various areas of the US will be generated for comparison with similar forecasts available from the University of Illinois and other centers (http://www.mmm.ucar.edu/wrf/REAL_TIME/real_time.html).

Begin planetary code generalization (Ewald, Graduate Students): the code will be modified to allow for user specified orbital and day/year length parameters, an alternate to the day-month-year calendar will be implemented, and all terrestrial constants pulled into a constants specification module that will allow them to be changed for different planets

Begin global GCM modifications (Toigo, Richardson): the mass model dynamical core will be modified to allow for cylindrical coordinates and will be tested.

We are slightly ahead of this schedule at this time.

Part 1 (validation of the released code) has been accomplished. The purpose of this task was to make sure that we were starting from a valid model base. We are comfortable that the version we ingested into our revision control system is a valid, working version of the NCAR WRF model.

Part 2 (planetary generalization) has been completed. The flexibility of the WRF code was suspected at the time of writing, but we were concerned that discipline within the code (especially essential areas like diffusion) had not been maintained. This suspicion was largely a result of our experience with the NCAR MM5 model – in many way WRF's predecessor.

In the event, model constants were grouped entirely into a model_constants module, expect for a few tens of references to terrestrial "reference" surface pressure (10^5 Pa). These have been found and made into constants taken from the model_constants module. The clocks and calendars have also been converted for general planetary use. A version of the Earth System Modeling Framework code exists in the NCAR WRF release. While overly cumbersome for our needs, we were able to write parts of it to yield an optional version, which we have termed the Planetary System Modeling Framework. The relationship between day number and seasonal date yielded by the code has been confirmed.

Part 3 (globalization) has, we think, been completed. We are currently validating for a Martian GCM version of WRF. This task involved conversion of the model numerical grid projection, the implementation of polar boundary conditions, and a polar fourier filter (for grid convergence issues). The result is a standard c-grid GCM. The trickiest part of the conversion was the map projection conversion, especially for diffusion.

Years 2 and 3 tasks:

The fast start on the project leaves more schedules to deal with aspects that could turn out to be harder than estimated in the proposal. Currently, the project has yielded a planetary GCM, which while useful, is nothing new. The major power of WRF will be in its reconfigurability, and nesting. These areas remain to be addressed:

Develop stand-alone one-dimensional model option for WRF:

- The ability to run WRF with no dynamics will be a powerful and extremely useful (time saving) capability. It will facilitate both rapid debugging of "physics" routines and science by allowing high-resolution boundary layer studies

Demonstrate nesting:

- One-way nesting – run a stand-alone WRF mesoscale simulation from output of the WRF GCM
- Two-way nesting – run nest(s) interactively within the global model

Alternative global projections:

- There is substantial advantage in developing a global project that does not have a singularity at the pole – for Mars this is especially the case, where science problems in the polar regions are some of the most important. The proposal had as a major task developing a global model version of WRF with two polar stereographic domains centered on the two poles and overlapping in the equator.
- Several GCM's have the ability to use "stretched" grid, such that one area of the surface can be focused-on with higher spatial resolution. The resolution smoothly decreases away from this point, and there is no nesting (the NASA GSFC Ares model and the French LMD models can both do this). To make such a capability in WRF should be relatively easy. Having this capability will allow the relative benefits of zooming vs. nesting to be tested.